

**APPLICATION FOR  
UNITED STATES PATENT**

**in the name of**

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**Of**

**Malden Mills Industries, Inc.**

**for**

**ELECTRIC HEATING/WARMING WOVEN FIBROUS  
ARTICLES**

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# ELECTRIC HEATING/WARMING WOVEN FIBROUS ARTICLES

## TECHNICAL FIELD

This application is: a continuation-in-part of U.S. Application No. 09/791,237, filed February 23, 2001, now pending, which is a continuation-in-part of U.S. Application No. 09/697,100, filed October 26, 2000, now pending, which is a continuation-in-part of U.S. Application No. 09/395,326, filed September 13, 1999, now U.S. Patent No. 6,160,246, issued December 12, 2000, which is a division of U.S. Application No. 09/296,375, filed April 22, 1999, now abandoned; a continuation-in-part of U.S. Application No. 09/592,235, filed June 12, 2000, now pending; and a continuation-in-part of U.S. Application No. 09/703,089, filed October 31, 2000, now U.S. Patent No. 6,307,189, issued October 23, 2001, which is a division of U.S. Application No. 09/468,627, filed December 21, 1999, now U.S. Patent No. 6,215,111, issued April 10, 2001; the complete disclosures of all of which are incorporated herein by reference.

The invention relates to woven, fibrous fabric articles that generate heat/warmth upon application of electricity.

## BACKGROUND

Fabric or fibrous heating/warming articles are known, e.g., in the form of electric blankets, heating and warming pads and mats, heated garments, and the like. Typically, these heating/warming articles consist of a body defining one or a series of envelopes or tubular passageways into which electrical conductance heating wires or elements have been inserted.

In some instances, the electric conductance heating wires are integrally incorporated into the body during its formation, e.g. by weaving or knitting. Relatively flexible electric conductance heating wires or elements, e.g., in the form of a core of insulating material, e.g., yarn, about which is disposed an electrical conductive element, e.g., a helically wrapped metal wire or an extruded sheath of one or more layers of conductive plastic, have been fabricated directly into the woven or knitted structure of a fabric body. For example, in Kishimoto U.S. 5,422,462, conductive yarns are selectively substituted for warp and/or weft yarns during formation of a woven body. The conductive yarns are then connected at their ends to a source of electrical current.

## SUMMARY

According to one aspect of the invention, a woven fibrous article adapted to generate heat upon application of electrical power comprises a woven fibrous body comprising a set of non-conductive warp yarns and a set of non-conductive filling or weft yarns, one of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns in one or more first regions comprising relatively more coarse yarns and in one or more second regions comprising relatively more fine yarns with electrical conductor elements extending generally along the second regions of the woven fibrous body, and the other of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns in the one or more first regions and in the one or more second regions comprising relatively more fine yarns, with a plurality of spaced apart electrical conductance heating elements in the form of conductive elements joined in the woven fibrous body with the other of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns to extend generally between opposite second regions of the woven fibrous body, the conductor elements being adapted to connect the plurality of spaced apart electrical conductance heating elements in a parallel electrical circuit to a source of electrical power.

Preferred embodiments of this aspect of the invention may include one or more of the following additional features. The woven fibrous article has fleece upon at least one surface of the woven fibrous body, formed by finishing fibers of the relatively more coarse yarns in the one or more first regions of the one of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns in a manner to avoid damage to electrical conductivity performance of the electrical conductance heating elements joined with the other of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns of the woven fibrous body. The woven fibrous body has fleece formed in the relatively more coarse non-conductive fibers upon one surface or upon both surfaces. In the one or more first regions, the set of non-conducting warp yarns comprises the relatively more coarse yarns and the set of non-conducting filling or weft yarns comprises the relatively more fine yarns. Preferably, the one or more second regions comprises selvedge or edge regions. Alternatively, in one or more first regions, the set of non-conducting filling or weft yarns comprises the relatively more coarse yarns and the set of non-conducting warp yarns comprises the relatively more fine yarns. Preferably, the one or more second regions comprises spaced regions with one or

more first regions disposed therebetween. The one or more second regions comprises a plurality of spaced second regions with one or more first regions disposed therebetween. A series of at least three electrical conductance heating elements of the plurality of electrical conductance heating elements are symmetrically spaced. Selected of the electrical conductance heating elements are asymmetrically spaced to provide selected localized regions of heating. Selected of the conductive elements have relatively lower linear resistance than other of the conductive elements, to provide selected localized regions of relatively greater heating. Selected of the conductive elements of relatively lower linear resistance are symmetrically spaced and/or asymmetrically spaced. The conductive elements have the form of a conductive yarn. The fibrous body comprises hydrophilic material and/or hydrophobic material. The electrical conductor elements are adapted for connecting the plurality of spaced-apart electrical conductance heating elements in the parallel electrical circuit to a power source, e.g., of alternating current or of direct current, e.g. a battery mounted to the woven fibrous body. The electrical conductor elements are woven into the second regions of the woven fibrous body, e.g., with the non-conductive warp yarns or with the non-conductive filling or weft yarns. The electrical conductor elements comprise at least two yarns. The electrical conductor elements, at least in part, are applied as a conductive paste. The electrical conductor elements comprise a conductive wire. The electrical conductor elements, at least in part, are applied as a conductive hot melt adhesive. The electrical conductor elements comprise a conductive yarn or a conductive thread. The electrical conductor elements are attached upon a surface in a second region of the woven fibrous body. The electrical conductor elements are attached: by stitching, e.g. embroidery stitching, by sewing, by adhesive, by laminating, by mechanical fastening, and/or by strain relief fastening. The electrical conductance heating element has the form of a conductive yarn comprising a core, an electrical conductance heating filament, a sheath material wrapped about the core, and/or an overwrap comprising insulating material wrapped about the core and the sheath. In one embodiment, the core may comprises the electrical conductance heating element and the sheath comprises insulating material. In another embodiment, the core comprises insulating material and the sheath wrapped about the core comprises the electrical conductance heating element. The electrical conductance heating element may instead have the form of a conductive yarn comprising an electrical

conductance heating filament. The electrical conductance heating element has electrical resistivity in the range of about 0.1 ohm/cm to about 500 ohm/cm.

According to one aspect of the invention, a woven fibrous article adapted to generate heat upon application of electrical power is formed by a method comprising the steps of:

5 joining a set of non-conductive warp yarns and a set of non-conductive filling or weft yarns to form a woven fibrous body, one of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns in one or more first regions comprising relatively more coarse yarns and in one or more second regions comprising relatively more fine yarns and the other of the set of non-conductive warp yarns and the set of non-conductive filling or weft

10 yarns in the one or more first regions and in the one or more second regions comprising relatively more fine yarns, joining, in the woven fibrous body, with the other of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns, the plurality of spaced apart electrical conductance heating elements in the form of conductive elements, to extend generally between opposite second regions of the woven fibrous body, and

15 connecting the plurality of spaced apart electrical conductance heating elements to electrical conductor elements extending generally along the second regions of the woven fibrous body to form a parallel electrical circuit for connection to a source of electrical power.

Preferred embodiments of this aspect of the invention may include the following additional feature. The method further comprises the step of: finishing relatively more coarse yarns fibers in the one or more first regions of the set of the non-conductive warp yarns and the set of non-conductive filling or weft yarns in a manner to avoid damage to electrical conductivity performance of the conductive elements joined with the other of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns of the woven fibrous body.

25 According to yet another aspect of the invention, a method of forming a woven fibrous article adapted to generate heat upon application of electrical power comprises the steps of: joining a set of non-conductive warp yarns and a set of non-conductive filling or weft yarns to form a woven fibrous body, one of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns in one or more first regions comprising relatively more coarse yarns and in one or more second regions comprising relatively more fine yarns and the other of the set of non-conductive warp yarns and the set of non-

conductive filling or weft yarns in the one or more first regions and in the one or more second regions comprising relatively more fine yarns, joining, in the woven fibrous body, with the other of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns, the plurality of spaced apart electrical conductance heating elements in the form of conductive elements, to extend generally between opposite second regions of the woven fibrous body, and connecting the plurality of spaced apart electrical conductance heating elements to electrical conductor elements extending generally along the second regions of the woven fibrous body to form a parallel electrical circuit for connection to a source of electrical power.

Preferred embodiments of this aspect of invention may include one or more of the following additional features. The method further comprises the steps of: finishing relatively more coarse yarns fibers in the one or more first regions of the set of the non-conductive warp yarns and the set of non-conductive filling or weft yarns in a manner to avoid damage to electrical conductivity performance of the conductive elements joined with the other of the set of non-conductive warp yarns and the set of non-conductive filling or weft yarns of the woven fibrous body. The method further comprises the step of connecting the conductive element to a source of electric power and generating heat. The method further comprises the step of connecting the conductive element to a source of electric power comprising alternating current and generating heat. The method further comprises the step of connecting the conductive element to a source of electric power comprising direct current, e.g. in the form of a battery, which may be mounted to the woven fibrous article, and generating heat. The method further comprises the step of rendering elements of the woven fibrous body hydrophilic or rendering elements of the woven fibrous body hydrophobic.

Objectives of the invention include to provide woven, fibrous electric heating articles, e.g. electric blankets, heating and warming pads, heated garments, etc., into which a plurality of spaced-apart electric conductance heating members, in the form of conductive elements, are joined with non-conductive yarns or fibers. The woven fibrous body of the heating article is subsequently subjected to a finishing process, e.g., relatively more coarse non-conductive yarns in selected (first) regions at one or both surfaces of the body may be napped, brushed, sanded, etc., in a manner to avoid damage to electrical conductance of the electric conductance heating elements, to form fleece. In a planar structure, such as an electric

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heating blanket, the electric conductance heating members are connected at their ends, e.g., in selected (second) regions of relatively more fine yarns along opposite selvedge or edge regions, or in spaced regions at opposite edges of first regions, of the planar body, i.e., of the blanket, and may be powered by alternating current or direct current, e.g., by one or more batteries mounted to the body of the woven fibrous heating/warming article.

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The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

## DESCRIPTION OF DRAWINGS

10 FIG. 1 is a perspective view of a woven fibrous electric heating article of the invention, e.g., in the form of an electric blanket or an electric mattress pad; and

FIGS. 2 and 3 are enlarged top plan views of selected regions of the woven fibrous electric heating article of FIG. 1, showing electrical conductance heating elements placed with predetermined symmetrical spacing and asymmetrical spacing, respectively.

15 FIGS. 4, 4A and 4B are end section views of different embodiments of woven fibrous electric heating articles of the invention, without a raised surface (FIG. 4), with fleece formed on one surface (FIG. 4A), and with fleece formed upon both surfaces (FIG. 4B).

FIG. 5 is a perspective view of another embodiment of a woven fibrous electric heating article of the invention in the form of an electric stadium blanket; and

20 FIGS. 6, 6A and 6B are end section views of the woven fibrous electric heating article of FIG. 5, without a raised surface (FIG. 6), with fleece formed on one surface (FIG. 6A), and with fleece formed upon both surfaces (FIG. 6B).

FIG. 7 is a perspective view of still another embodiment of a woven fibrous electric heating article of the invention in the form of an electric heating pad; and

25 FIGS. 8, 8A and 8B are end section views of the woven fibrous heating article of FIG. 7, without a raised surface (FIG. 8), with fleece formed on one surface (FIG. 8A), and with fleece formed upon both surfaces (FIG. 8B).

FIG. 9 is a somewhat diagrammatic end section view of a preferred embodiment of an electric conductance heating yarn for a woven fibrous electric heating article of the invention,

while FIGS. 10-13 are similar views of alternative embodiments of electric conductance heating elements for woven fibrous electric heating articles of the invention.

FIG. 14 is a top plan view of an edge region of an alternative embodiment of a woven fibrous electric heating article of the invention, with a conductive bus attached externally in an edge region; and

FIG. 15 is an end section view of the edge region of a woven fibrous electric heating article of the invention taken at the line 15-15 of FIG. 14.

FIG. 16 is a top plan view of an edge region of another alternative embodiment of a woven fibrous electric heating article of the invention, with a conductive bus attached externally in an edge region.

FIGS. 17, 18 and 19 are somewhat diagrammatic representations of other embodiments of woven fibrous electric heating articles of the invention, including as adapted to be powered by direct current, e.g., a stadium or camping blanket (FIG. 17) and a garment (FIG. 18), each adapted to be powered from a battery replaceably mounted to the article; and an automobile warming or heating pad (FIG. 19), adapted to be powered from an automobile battery.

FIGS. 20 and 21 are somewhat diagrammatic perspective views of other embodiments of electric heating/warming articles of the invention formed of two or more layers.

Like reference symbols in the various drawings indicate like elements.

#### DETAILED DESCRIPTION

Referring to FIG. 1, in a first embodiment, a woven fibrous article 10 of the invention, e.g., an electric blanket or an electric mattress pad, is adapted to generate heat upon application of electrical power. The woven fibrous article consists of a woven body 12 formed of a set 14 of non-conductive yarns extending in the warp direction (arrow, W) woven with a set 16 of non-conductive yarns extending in the weft or filling direction (arrow, F). In this first embodiment, the set 14 of non-conductive warp yarns, in a first or central region 18, consists of relatively more coarse yarns 20 formed of filaments or spun fibers made of non-conducting insulating material, e.g., such as polyester, acrylic, nylon, cotton, wool, or the like, and the set 16 of non-conductive warp yarns, in one or more second

regions, e.g., edge or selvedge regions 22, consists of relatively finer yarns 24 formed of filaments or spun fibers. A conductive bus 26, e.g., a single yarn or multiple yarns in parallel (as shown), to further reduce resistance, extends along the edge or selvedge regions 22. Still in this first embodiment, the set 16 of non-conductive filling or weft yarns consists of 5 relatively finer yarns 28 formed of filaments or spun fibers made of non-conductive insulating materials, e.g., such as polyester, acrylic, nylon, cotton, wool, or the like, and electrical conductance heating yarns 30 placed with predetermined spacing. For example, the electrical conductance heating yarns 30 may be spaced apart symmetrically (e.g., spacing, S<sub>1</sub>, FIG. 2) and/or the electrical conductance heating yarns 30 may be spaced apart 10 asymmetrically, with varying spacing (e.g., spacing, S<sub>2</sub> and S<sub>3</sub>, FIG. 3), in order to generate different amounts of heat in different predetermined regions. The electrical conductance heating yarns 30 may also be made of yarns of relatively different linear resistance spaced apart symmetrically and/or asymmetrically, again to generate different amounts of heat in 15 different predetermined regions. The spacing is typically a function, e.g., of the requirements of heating, energy consumption and heat distribution in the article to be formed. For example, the spacing of electrical conductance heating yarns 30 may be in the range of from about 0.02 inch to about 2.5 inches. However, other spacing may be employed, depending on the conditions of intended or expected use, including the resistivity of the conductive yarns.

According to one preferred embodiment of the invention, the woven fibrous body 12 incorporating the electric conductance heating elements 30 can be completed in an unfleeced state, e.g., for use as an electric mattress pad 11, as shown in FIG. 4, or the like.

Alternatively, according to other preferred embodiments of the invention, the woven fibrous body 12 incorporating the electric conductance heating elements 30 may next be subjected to finishing, e.g., sanding, brushing, napping, etc., to generate a fleece or raised surface. For example, fleece 32 may be formed on one surface of the woven body 12 (FIG. 25 4A), or fleece 34, 34' may be formed on both surfaces of the woven body 12' (FIG. 4B). In either case, the process of generating fleece on the surface or surfaces of woven body is preferably performed in a manner to raise the relatively more coarse yarns 20 in the first 30 region 18, while the relatively finer warp yarns 24 with the conductive bus 26 in the second regions, as well as the relatively finer, tight weft or filling yarns 28 (e.g., high level of twist, high level of tie down), are not raised. The finishing process is also conducted in a manner to

5 avoid damage to the electrical conductance heating yarns 30, like those made with stainless steel filaments, that are part of the construction of the woven body 12 in the weft or filling direction (arrow, F). In particular, fleece 32 (or fleece 34, 34') is formed in a manner that avoids damage to the conductive filaments of the electrical conductance heating yarns 30 that would result in an increase in resistance to the point of creating an undesirable local hot spot, or would sever electrical conductance heating yarns 30 completely, which could result in undesirable increased electrical flow elsewhere in the circuit. The material of the woven body 12 may also be treated, e.g. chemically, to render the material hydrophobic or hydrophilic.

10 Referring to FIG. 5, in a second embodiment of a woven fibrous article of the invention, e.g., an electrical stadium blanket 40, or other electrical blanket, adapted to generate heat upon application of electrical power, a woven body 42 is formed of a set 44 of non-conductive yarns extending in a warp direction (arrow, W) and a set 46 of non-conductive yarns extending in a weft or filling direction (arrow, F). In this second embodiment, the set 44 of non-conductive warp yarns consists of relatively finer yarns 48 formed of filaments or spun fibers made of non-conductive insulating materials, e.g., such as polyester, acrylic, nylon, cotton, wool, or the like, and electrical conductance heating yarns 50 spaced apart with predetermined spacing. (As described above, the electrical conductance heating yarns 50 may be spaced apart symmetrically and/or the electrical conductance heating yarns 50 may be spaced apart asymmetrically, in order to generate different amounts of heat in different predetermined regions, and/or the electrical conductance heating yarns 50 may be made of yarns of relatively different linear resistance, spaced apart symmetrically or asymmetrically, again to generate different amounts of heat in different predetermined regions.) Still in this second embodiment, the set 46 of non-conductive filling or weft yarns, 15 in a first or central region 54, consists of relatively more coarse yarns 52 formed of filaments or spun fibers made of non-conducting insulating materials, e.g., such as polyester, acrylic, nylon, cotton, wool, or the like, and the set 46 of non-conductive filling or weft yarns, in one or more second regions, e.g., edge or selvedge regions 58, consists of relatively finer yarns 60 formed of filaments or spun fibers. Conductive yarns or buses 62, formed, e.g., of one 20 yarn (as shown) or multiple yarns in parallel, extend along the edge or selvedge regions 58.

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As described above, the woven fibrous body 42 incorporating the electric conductance heating elements 50 may be completed in the form of an electrical blanket 41 in its unfleeced state (FIG. 6). Alternatively, it may next be subjected to finishing, e.g., sanding, brushing, napping, etc., to generate a fleece. Fleece 64 may also be formed on one surface of the woven body 43 (FIG. 6A), or fleece 66, 66' may be formed on both surfaces of the woven body 43' (FIG. 6B). In either case, the process of generating the fleece on the surface or surfaces of woven body is preferably performed in a manner to raise the relatively more coarse yarns 52 in the first region 54, while the relatively finer weft or filling yarns 60 with the conductive bus 62 in the second regions, as well as the relatively finer, tight warp yarns 48 (e.g., high level of twist, high level of tie down), are not raised. The finishing process is also conducted in a manner to avoid damage to the electrical conductance heating yarns 50, like those made with stainless steel filaments, that are part of the construction of the woven body 42 in the weft or filling direction (arrow, F). In particular, the fleece 64 (or fleece 66, 66') is formed in a manner that avoids damage to the conductive filaments of the electrical conductance heating yarns 50.

Referring to now to FIG. 7, in a further embodiment of a woven fibrous article of the invention, e.g., an electric heating pad 70, adapted to generate heat upon application of electrical power, a woven body 72 is formed of a set 74 of non-conductive yarns extending in the warp direction (arrow, W) and a set 76 of non-conductive yarns extending in the filling or weft direction (arrow, F). In this embodiment, the set 74 of non-conductive warp yarns consists of relatively fine yarns 78 formed, e.g., of filament 30-500 denier like polyester, nylon, polypropylene, or spun yarn made of 60/1 to 5/1 cotton count like synthetic acrylic, polyester, nylon, or natural fibers like cotton, wool or regenerated fiber like rayon, and electrical conductance heating yarns 80 spaced apart with predetermined spacing, e.g., as described above with respect to other embodiments of the invention. The electrical conductance heating yarn can be used alone as part of the warp yarn, or plaited with another warp insulator yarn during the weaving. The set 76 of non-conductive filling or weft yarns, in sequential first or central regions 82, arrayed in the warp direction (arrow, W), consists of relatively more coarse yarns 84 formed, e.g., of coarse spun yarn 1/1 to 20/1 cotton count or coarse filament yarn 300 to 5000 denier. The fibers are formed of insulating materials or like,

such as synthetic fibers; polyester, nylon, acrylic, polypropylene or natural fibers; cotton, wool, or regenerated fiber like rayon. The fibers may also be a blend. At predetermined distances along the length of the fabric, in second regions 86 extending in the weft or filling direction (arrow, F) along the borders of the first regions 82, the set 76 of non-conductive 5 weft or filling yarns consists of relatively finer yarns 88 formed, e.g., of finer filling yarn, preferred with higher twist and higher tie down (tucking), in filament or spun yarn. At each second region 86, conductive buses 90, formed by insertion of relatively low resistance electrically conductive yarns, e.g., group of yarns separated by insulator yarns 88, to further reduce resistance, as weft or filling yarns, extending along the second regions in the weft or 10 filling direction.

Once again, as described above, the woven fibrous body 72 incorporating the electric conductance heating elements 80 may be completed in the form of an electrical heating pad 71 in its unfleeced state (FIG. 8). Alternatively, it may next be subjected to finishing, e.g., sanding, brushing, napping, etc., to generate a fleece. Fleece 92 may also be formed on one 15 surface of the woven body 73 (FIG. 8A), or fleece 94, 94' may be formed on both surfaces of the woven body 73' (FIG. 8B). In either case, the process of generating the fleece on the surface or surfaces of woven body is preferably performed in a manner to raise the relatively more coarse weft or filling yarns 84 in the first regions 82, while the relatively finer weft or filling yarns 88 with the conductive bus 90 in each of the second regions 86, as well as the 20 relatively finer, tight warp yarns 78 are not raised. The finishing process is also conducted in a manner to avoid damage to the electrical conductance heating yarns 80, like those made with stainless steel filaments, that are part of the construction of the woven body 72 in the warp direction (arrow, W).

Referring to FIG. 9, in one preferred embodiment, e.g., as described above with 25 respect to the electric blanket 10 of FIG. 1, the conductive yarn 100 forming the electrical conductance heating elements 30 consists of a core 102 of insulating material, e.g. a polyester yarn, about which extends an electrical conductive element 104, e.g. three filaments 106 of stainless steel wire (e.g. 316L stainless steel) wrapped helically in a sheath about the 30 core 102, and an outer covering or overwrap 108 of insulating material, e.g. polyester yarns 110 (only a few of which are suggested in the drawings) helically wrapped about the core

102 and the filaments 106 of the electrical conductive element 30. The conductive yarn 100 is available, e.g., from Bekaert Fibre Technologies, Bekaert Corporation, of Marietta, Georgia, as yarn series VN14.

The number of conductive filaments in the conductive yarn, and the positioning of the 5 conductive filaments within the conductive yarn, are dependent, e.g., on end use requirements. For example, in alternative configurations, in FIG. 10, a conductive yarn 100' has four conductive filaments 106' wrapped as a sheath about a non-conductive core 102' with a non-conductive outer covering or overwrap 108' of polyester yarns 110'. In FIG. 11, a conductive yarn 100" has a conductive core of three filaments 106" wrapped in a non- 10 conductive outer sheath 108" of polyester yarns 110", without an overwrap. Referring to FIGS. 12 and 13, and also referring to FIG. 1, in other embodiments, conductive yarns 112, 112', respectively, are formed without an outer covering about the conductive filaments 114, 114'. The conductive filaments 114 may be wrapped in a sheath about a non-conductive core 116 (FIG. 12), or the conductive filaments 114' may be in the form of a twisted stainless steel 15 wire (FIG. 13). In these embodiments, the non-conductive warps yarns 20, 24 and the non-conductive weft or filling yarns 28 of the woven body 12, in particular, the relatively more coarse yarns, either fleeced or unfleeced, serve to insulate the conductive yarns 112, 112' in the woven fibrous heating/warming fabric article.

The resistivity of the conductive yarn 30 can be selected in the range of, e.g., from 20 about 0.1 ohm/cm to about 500 ohm/cm, on the basis of end use requirements of the woven fibrous article. However, conductive yarns performing outside this range can also be employed, where required or desired. Referring again, by way of example, to FIG. 9, the core 102 of the conductive yarn and the sheath material 108 of the outer covering over the conductive filaments 106 may be made of synthetic or natural material. The outer covering 25 108 may also have the form of a sleeve, e.g. a dip-coated or extruded sleeve. Conductive yarns of different constructions suitable for use according to this invention can also be obtained from Bekaert Fibre Technologies.

Referring now to FIGS. 14 and 15, and also with reference to FIG. 1, use of relatively 30 finer yarns 24, 28 in the edge or selvedge regions 22, in the warp and weft or filling directions, respectively, e.g., as compared to the coarse yarns 20 of the first region 18,

alternatively permits use of conductive buses 120 that are appended externally, e.g. along the surfaces 122 of the edge or selvedge regions 22. It also provides for external securing of the connection between the electrical conductance heating yarns 30 and the external conductive buses 120. For example, after finishing, and after the woven body is heat set for width,  
5 conductive buses 120 are provided in opposite edge regions 22 to connect spaced apart electrical conductance heating yarns 30, in parallel, to a source of electrical power, thereby to complete the electrical circuit. The conductive buses 120 may be formed or attached upon either surface, or upon both surfaces, of the woven body 124.

Alternatively, the conductive bus 120 may instead be applied before, or in the absence of, finishing (and/or before heat setting), since the conductive buses 120 are advantageously located in the second edge or selvedge regions 22 of the relatively finer yarns 24, 28 (which are not finished), and not in a first or central region 18 of the relatively more coarse yarns 20. Any suitable method may be used to complete the circuit. For example, the conductive buses 120 may consist of one conductive yarn, e.g., with a resistivity of, e.g., 0.1 to 100 ohm per meter, or of multiple (e.g. two or more) conductive yarns, thus to reduce resistance and to ensure a more positive connection between the electric conductance heating elements and the conductive buses. The conductive bus 120 may, at least in part, be applied in the form of a conductive paste, e.g. such as available commercially from Loctite Corporation, of Rocky Hill, Connecticut. The conductive paste may be applied as a stripe to a surface of the woven body 124 in electrical conductive relationship with the electrical conductance heating elements 30, and then connected to the power source. (If necessary, the conductive filaments of the electrical conductance heating elements 30 may be exposed, e.g., a covering yarn may be removed with solvent or localized heat, e.g. by laser; or the covering yarn may be manually unraveled, thus to facilitate accessibility to conductive filaments of each of the electrical conductance heating yarns.) More preferably, the conductive buses 120, in the form of conductive yarn or thread, are attached upon the surface 122 of the woven body 124, e.g., by stitching, e.g. embroidery stitching, sewing, or with an adhesive, such as by laminating. Alternatively, referring to FIG. 16, and again with reference to FIG. 1, the conductive bus 130 may consist of localized dots or regions 132 of conductive paste applied in electrical contact with exposed conductive filaments of the electric conductance heating yarns 30, with a conductive metal wire 134 disposed in electrical conductive contact with,

and extending, preferably continuously, between, the localized conductive paste regions 132. The electric conductive bus 130 may thereafter be covered by a layer of fabric material 136 joined to overlay a portion or substantially all of the surface of the selvedge regions 122 of the woven body 124, e.g., in the form of a cloth trim or edging material attached, e.g., by stitching along the edge of the woven body 124, or in the form of a second layer of fabric joined to woven body 124, e.g., by stitching or lamination.

A conductive bus of the woven fibrous electric heating article of the invention is preferably flexible, corrosion resistant, with low electrical resistivity, e.g. 0.1 ohm/meter to 100 ohm/meter, and mechanically durable. Other considerations include cost, availability in the market, and ease of fabrication. The conductive bus may thus have the form of a wire, e.g., stranded, twisted, or braided; a conductive-coated textile, e.g., a coated filament or fabric, or a woven ribbon; a foil tape, e.g., adhesive backed, with or without a conductive backing; a conductive-filled resin, e.g., disposed in a continuous line; or a hybrid textile, e.g., including tinsel wire or stainless steel filaments, in twisted, braided, stranded, woven or knitted configuration. As mentioned above, the conductive bus may also have the form of a single yarn, or two or more generally parallel yarns, woven into or stitched upon the fabric body, or a tape or band of conductive material attached upon the surface of the fabric. In a presently preferred form, the conductive bus may be a narrow woven element, incorporating silver-coated copper tinsel wire, either multi-strand or individual strands in parallel, with periodic floats provided for contact with the conductive yarns, or a narrow woven element pre-coated with conductive thermoplastic in a stripe pattern, with discontinuous diagonal stripes to provide flexibility and ensure registration with conductive yarns. The conductive bus may also extend in multiple elements extending generally parallel in the edge region of the fabric, with similar or different lengths, to connect to distinct sets of electrical conductance heating yarns, in this manner reducing the level of electrical current carried by each conductive bus in the region close to the source of electrical power. In the case of conductive buses of different lengths, the resistivity of the individual conductive buses may be different.

The conductive bus 120 is preferably mounted upon the surface of the woven body 124 in a manner to provide strain relief. For example, strain relief attachment may be provided by sewing the conductive bus 120 to the woven body 124, by tacking the

conductive bus 120 upon the surface of the body 124 with mechanical fasteners, such as  
snaps, grommets, staples, or rivets; by over-molding in place strain relief injection-molded  
“buttons”; or by incorporating strain relief and electrical connection rigid filled resin having  
low viscosity. The electrical conductance heating yarns 30 and conductive bus 120 may be  
5 connected electrically by conductive welding or paste; rivets, snaps, or metal holders or  
fasteners; interlacing, knitting or weaving in, or combinations of the above.

The completed circuit is next connected to a power source to supply electrical power  
to the electrical conductance heating elements for the required amount of heat generation. For  
10 example, referring to FIG. 1, a woven fibrous article 10 of the invention (an electric blanket)  
is adapted for connection to a source of alternating current by means of plug 130 on cord 132  
for insertion in household outlet 134. Referring to FIGS. 17 and 18, a stadium or camping  
blanket 140 and a garment 150 of the invention each includes a source of direct current, i.e. a  
15 battery pack 142, 152, respectively, e.g., as available from Polaroid Corporation, of  
Cambridge, Massachusetts, replaceably mounted to the heating/warming fabric article, e.g. in  
a pocket 144, 154, respectively. Referring to FIG. 17, the pocket may be secured by a hook-  
and-loop type fastener 146. Preferably, for certification by Underwriters Laboratories Inc.  
(UL®), the voltage supplied by the power source to the electrical conductance heating  
elements is lower than 25 volts, e.g. a Class II UL® certified transformer may be used to step  
down a 110v power supply to 25 volts or under. Referring next to FIG. 19, a warming or  
heating pad 160 of the invention, e.g. for an automobile seat, is adapted for connection to a  
20 source of direct current by means of plug 162 on cord 164 for insertion into the cigarette  
lighter or other power outlet 166 of an automobile.

The resulting product is a woven fibrous electric heating article, e.g., an electric  
25 blanket 90 inches by 90 inches with a 24-volt power supply, with features not available with  
blankets currently on the market. In a preferred embodiment, the fibrous woven article has  
the characteristics of being: flexible, foldable, portable, able to be washed frequently,  
comfortable, with zone heating and low voltage (for increased safety).

30 A number of embodiments of the invention have been described. Nevertheless, it will  
be understood that various modifications may be made without departing from the spirit and

scope of the invention. For example, woven fibrous electric heating articles of the invention may be formed by any suitable method that results in a woven body formed of non-conductive fibers and conductive elements capable of generating heating when connected to a source of electrical power, and, as desired, or as designed, with non-conductive fibers being exposed, e.g., in predetermined regions, for finishing at one or both surfaces to create fleece, the finishing being performed in a manner to avoid damage to electrical conductivity performance of the electrical conductance heating elements joined with the non-conductive fibers in the woven body.

Referring to FIGS. 20 and 21, woven fibrous electric heating article of the invention may also be employed in the form of laminated devices for delivering therapeutic heat to a selected region of the human body. For example, for delivering therapeutic heat upon a relatively large surface region, e.g., of the back or thigh, the heating/warming device 170 may be in the form of a wrap or sleeve, with a woven fibrous electric heating article 172 of the invention disposed between opposite fabric layers 174, 176. For delivery of heating/warming to a more local region, a heating/warming device 180 may be in a form suitable for mounting to a strap or brace with a woven fibrous electric heating article 182 of the invention laminated with a covering layer of fabric 184.

Accordingly, other embodiments are within the following claims.